Response of N-cycling Variables to Flow and Water Level Manipulations in Navigation Pools 5 and 8 of the Upper Mississippi River (UMR)

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Nitrate-N removal via denitrification in the UMR is highest in backwater and impounded regions, particularly during high river discharge when flood waters carry large quantities of nitrate to these areas. Further, floods during warm periods provide more optimal temperature for bacteria denitrification. Several management techniques are currently in practice in large flood plain rivers that may promote nitrate removal and improve water quality. First, water level management or pool drawdown attempts to mimic the historic natural hydrograph and is used primarily to increase growth of rooted aquatic plants and stabilize flocculent sediments. Second, engineered flows into backwater lakes has been used primarily to increase winter water temperatures and oxygen concentrations to improve fish production. Both management techniques likely impact elements of nitrogen cycling.

During the drawdown of Navigation Pool 8 in 2001, limited sampling sediment N characteristics in and out of the drawdown zone indicated decreased total N in the dried sediments. However, more extensive sampling during the 2002 Pool 8 drawdown showed rates of denitrification and nitrification declined in the impacted (dried sediment) portion of the Pool relative to pre-drawdown conditions. However, sediment ammonium declined significantly during drawdown, as did plant growth and plant N content. Mass balance implies the reduced sediment ammonium was likely a result of plant uptake, not microbial processing of N. Recovery of these processes on re-wetting was slow. The large unknown is the fate of plant-derived organic N; mineralization and flux of organic N after fall senescence is unknown but likely represents a large loss from the system. We are currently studying plant-N dynamics during the drawdown of Pool 5.

Directing water with high NO_3^- concentrations into backwaters through flow-control structures may increase NO_3^- removal rates throughout the flood plain. Controlled inflow into a set of lakes (the Finger Lakes) directly downstream from Lock and Dam 4 provided a good test of this hypothesis. Third Lake, a 15 ha backwater lake receiving high N water from the upstream Navigation Pool 4, exhibited high rates denitrification (22 μg-N $\cdot$ cm^{-2} $\cdot$ d^{-1}), limited by NO_3^- loading and tightly coupled with nitrification. Nitrate retention was linear to load (r^2=0.95), with greatest retention occurring in late June. An average of 48 kg - N $\cdot$ d^{-1} NO_3^- was removed from Third Lake (~ 43 % of total inflow load, ~ 32 % via denitrification). The remaining N loss was likely a function of assimilation by periphyton, bacteria, and macrophytes, and represents temporary storage, not a permanent loss. We are currently undertaking studies to determine NO3 uptake by periphyton with 13N tracer experiments.

These results show NO_3^- removal from backwater lakes is directly related to river-flood plain connectivity, river discharge, and NO_3^- loading rate. Engineered reconnection of backwaters to main channels could reduce downstream flux of NO_3^- while also restoring other ecologic functions and meeting multiple management goals.

Of these two major management actions, engineered backwater reconnection likely provides the greatest potential for N removal (relative to water level management) because of the relative ease of N-load control. The primary obstacle for an engineered solution is the initial cost of construction.